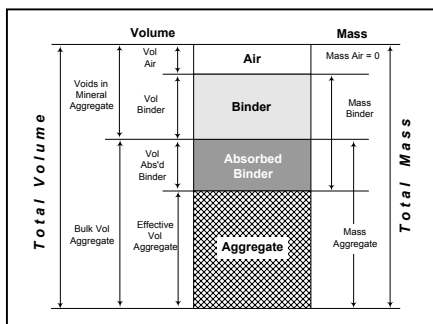


BASICS OF ASPHALT



Slice through asphalt core



HMA phase diagram

Introduction

Asphalt cement concrete (ACC) is a mixture of two primary ingredients: mineral aggregate and asphalt cement (AC) or asphalt binder as it is now termed. The binder holds the aggregate together in a moderately flexible rock-like mass. Hot mix asphalt (HMA) includes mixes that are produced at an elevated temperature. ACC and HMA are generally divided into three types of mixes, depending on the gradation of aggregate: dense-graded, open-graded, and gap-graded.

Dense-graded HMA consists of binder and well-graded aggregate evenly distributed from small to large particles. Open-graded HMA consists primarily of coarse aggregate, minimal fine aggregate, and binder. The mixture provides a very open surface texture — one that allows water to drain into the mix and in which large aggregate, stone-to-stone contact handles the load of a vehicle traveling over the surface. Gap-graded HMA is similar to open-graded mix, except that mid-size aggregate between the 4.75 mm (No. 4) and 425 μm (No. 40) sieves is missing or present only in small amounts.

HMA contains air voids in addition to aggregate and binder. Also, the binder is divided into two categories: absorbed (into the aggregate) and effective (which remains on the surface for binding aggregate particles together).

Five factors affect pavement performance: structural design of pavement layers, mix design properties, workmanship used to produce, place, and compact the mix, loading factors, and environmental conditions. The best specifications, if not followed, will not assure a high quality, long-lasting pavement. The best mix design, if not duplicated at the plant, will not guarantee the life of the pavement. The most sophisticated equipment, if not operated properly, will not produce a roadway that withstands the effects of traffic and the environment. Poor workmanship can negate all

those items and cause premature failure of pavement materials and / or pavement structure. High quality materials testing and construction inspection are critical to a successful project.

Design Parameters

07 Whether a mix design is developed through a Marshall, Hveem, or Superpave mix design process there are basic volumetric requirements of all.
08 Volumetrics can include Bulk specific gravity, theoretical maximum specific gravity, air voids, and voids in mineral aggregate.

09 The total mass of the mix includes entrapped air, moisture, effective and absorbed binder, and mineral aggregate. This total mass divided by the corresponding bulk or total volume of a specimen yields a number known as bulk density. Bulk density is calculated by determining the bulk specific gravity, G_{mb} , of the sample and multiplying by the density of water.

10 There are two procedures for calculating G_{mb} – suspension and volumeter. In the suspension procedure, G_{mb} is calculated as follows.

$$G_{mb} = \frac{A}{B - C}$$

where:

- G_{mb} = Bulk specific gravity
- A = Mass of dry, compacted specimen in air
- B = Mass of saturated surface dry (SSD) compacted specimen in air
- C = Weight of compacted specimen in water at 25°C (77°F)

11 The combined masses of binder and aggregate divided by the volume of these components only is the maximum density. This density is “maximum” in that it contains no air voids. The maximum density provides a reference or base used to determine the amount of air actually present in the

mix, among other things. Maximum density is determined on uncompacted HMA by determining the theoretical maximum specific gravity, G_{mm} , and multiplying by the density of water.

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There are two procedures for calculating G_{mm} – bowl and flask. In the flask procedure, G_{mm} is calculated as follows.

$$G_{mm} = \frac{A}{A + D - E}$$

where:

G_{mm} = Theoretical maximum specific gravity

A = Mass of dry specimen in air

D = Mass of flask filled with water at 25°C (77°F)

E = Mass of flask filled with water and specimen at 25°C (77°F)

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Air voids are expressed as a percentage of total sample volume. Percent air voids, V_a , is calculated as follows.

$$V_a = ((G_{mm} - G_{mb})/G_{mm}) \times 100$$

where:

V_a = Percent air voids of total mix mass

G_{mb} = Bulk specific gravity of compacted mix

G_{mm} = Theoretical maximum specific gravity

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Voids between aggregate particles may contain air or binder. Voids in the mineral aggregate, VMA, are those spaces in laboratory compacted specimens that include air and effective, but not absorbed, binder.

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$$VMA = 100 - \left[\frac{(G_{mb} P_s)}{G_{sb}} \right]$$

where:

VMA = Voids in the mineral aggregate

G_{mb} = Bulk specific gravity of compacted mix

G_{sb} = Bulk specific gravity of aggregate

	<p>P_s = Percent aggregate content in mix by mass of total mix</p>
16	<p>Finally, the voids filled with asphalt (VFA) is expressed as the percentage of the VMA that contains asphalt.</p> $VFA = ((VMA - V_a) / VMA) \times 100$ <p>where:</p> <p>VFA = Voids filled with asphalt VMA = Voids in the mineral aggregate V_a = Percent air voids by total mass of mix</p> <p>The above parameters are used in developing HMA mix design. These items should be systematically monitored during construction to ensure a quality product.</p> <p>Asphalt Cement Binder</p> <p>17 In the past, asphalt cement (AC) was graded by either penetration (AASHTO M 20) or viscosity (AASHTO M 226). Penetration graded asphalts were specified by a measurement by a standardized penetrometer needle under a standard load at a standard temperature. Penetration graded asphalts were typically expressed as “Penetration Grade 85-100”, meaning that the needle penetration was between 85 and 100 millimeters. The higher the penetration, the softer the AC.</p> <p>Viscosity graded asphalts were specified by determining the viscosity of AC. A temperature of 60°C (140°F) was considered to be a typical summer pavement temperature, and at this temperature, the unit of viscosity used was the poise. Standard terminology referred to AC-10 and AC-20, meaning that the viscosity of the AC was 1000 or 2000 poise, respectively. AC-20 was thicker or harder than AC-10. A temperature of 135°C (275°F) was considered the mixing and handling control point. At this temperature,</p>

different laboratory equipment was used and the unit of viscosity used was the centistoke (Cs).

In 1994, the industry formally accepted and began to implement years of research done under the Strategic Highway Research Program (SHRP). SHRP developed a new system of design for asphalt paving materials known as Superpave™. A new concept calling for performance grading was introduced.

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Performance Graded (PG) asphalt binders were introduced experimentally in 1994 and industry now uses PG specifications. The PG system of specifying binder is based on a complex series of performance based tests. The new specification system no longer refers to asphalt cement, but rather to binder, which includes modified and unmodified asphalts.

The new system specifies asphalt binders as PG followed by two numbers, for example PG 64-22. The first number is always higher and positive, while the second number is smaller and negative. The first number represents the expected average 7-day high pavement temperature, while the second number represents the expected single low pavement temperature. Both numbers referred to are in degrees Celsius.

Types of Manufacturing Plants

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Two common types of plants are drum plants and batch plants. Both types are capable of producing the same quality HMA. One is not better than the other. These plants are similar in that both have cold feed systems for aggregate. Material of different sizes is dropped from bins onto belts, transported to a mixer, blended, and then dropped onto another belt for transport to the dryer. The plants are different in the means of production following heating in the dryer.



Aggregate feed bins

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Drum Plants – In drum plants, scales under the belts from each bin control the mass flow rate of each aggregate size. Moisture corrections are applied in order to base the process on dry mass. Binder flow rate is controlled by a metered delivery

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Aggregate feed

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pump. Aggregate and binder are mixed in the far end (near the exit) of the drum and then stored temporarily in a silo.

With a drum plant supplying HMA to a single project, the aggregate and binder, as measured by the scales and meter, can be compared with the material delivered to the job. After accounting for waste and reject, binder quantity, as measured by field tests, should agree within 1 percent with the quantity metered at the plant. The total mass of the aggregate and binder measured at the plant should agree within 2 percent of total mass delivered to the site as measured by the platform scales over which the delivery trucks pass.

Drum plants are typically used for large jobs and are more portable. Drum plants continuously feed aggregate and binder into the drum, and produce large quantities of HMA during the course of a run. Drum plants, however, cannot switch mix designs with ease and require close control of material being fed to the dryer. Drum plants produce the same mix over an extended period, not several different mixes in a day as with batch plants.

Batch Plants – In batch plants, aggregate is rescreened and stored in separate bins after drying. Aggregate is taken from each bin on the basis of the mass called for in the mix design – the mass being determined in the aggregate hopper. A separate hopper is used for determining the mass of the binder. Aggregate and binder are mixed in a chamber, or pugmill, and then dropped into a truck or stored temporarily in a silo.

Batch plants are used where different mix designs are often needed. Batch plants are less efficient than drum plants because they only mix a certain amount of HMA at a time. They are more flexible, however, because several mixes can be made in a day. In fact, a batch plant can switch from one mix to another fairly quickly, as long as both mixes use aggregates from the same source.

Summary

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High quality hot mix asphalt requires a proper

combination of materials and workmanship. The testing technician plays a critical role in helping assure that materials incorporated into a roadway meet the requirements of the proper specification. No amount of proper workmanship can compensate for poor material quality.

